Household vulnerability to food insecurity due to climate change in Niger: a multinomial logistic regression of food insecurity categories on climate and socioeconomic factors.

Dr Elhadji Iro ILLA, University Abdou Moumouni of Niamey, department of Economics
elhadjijo@yahoo.fr ; illairo2016@gmail.com

Abstract

The methodology adopted is to identify a number of variables that characterize the dimensions of classic analysis of food security at household level. The variables identified for this purpose are food consumption score, livestock ownership and expenses. After multinomial logistic regression, the probability for a household to be severely food insecure, moderate or at risk, decreases with the following: animal possession, household age, the number of fields or gardens cultivated, agricultural/tools/seeds spending, consumption of milk/fruits/meat. The probability for a household to be severely food insecure, moderate or at risk, increases with the following: household size, the share of household spending devoted to education, experiencing climate stress event such as flood and drought.

Keywords: Food insecurity, climate stress, rural households.
JEL : Q1, Q54, R2, R3

Résumé

La méthodologie adoptée consiste à identifier un certain nombre de variables qui caractérisent les dimensions de l'analyse classique de la sécurité alimentaire au niveau ménage. Les variables identifiées à cet effet sont le score de consommation alimentaire, la possession de bétail et les dépenses. Après une régression logistique multinomiale, la probabilité pour un ménage d'être en insécurité alimentaire grave, modérée ou à risque diminue avec les éléments suivants : possession d'animaux ; âge du ménage ; nombre de champs ou de jardins cultivés ; dépenses en agriculture / outils / semences ; consommation de lait / de fruits / de viande. La probabilité pour un ménage de souffrir d'insécurité alimentaire grave, modérée ou à risque augmente avec les éléments suivants : la taille du ménage ; la part de ses dépenses consacrées à l'éducation ; la survenance d'un événement de stress climatique tel que les inondations et la sécheresse.

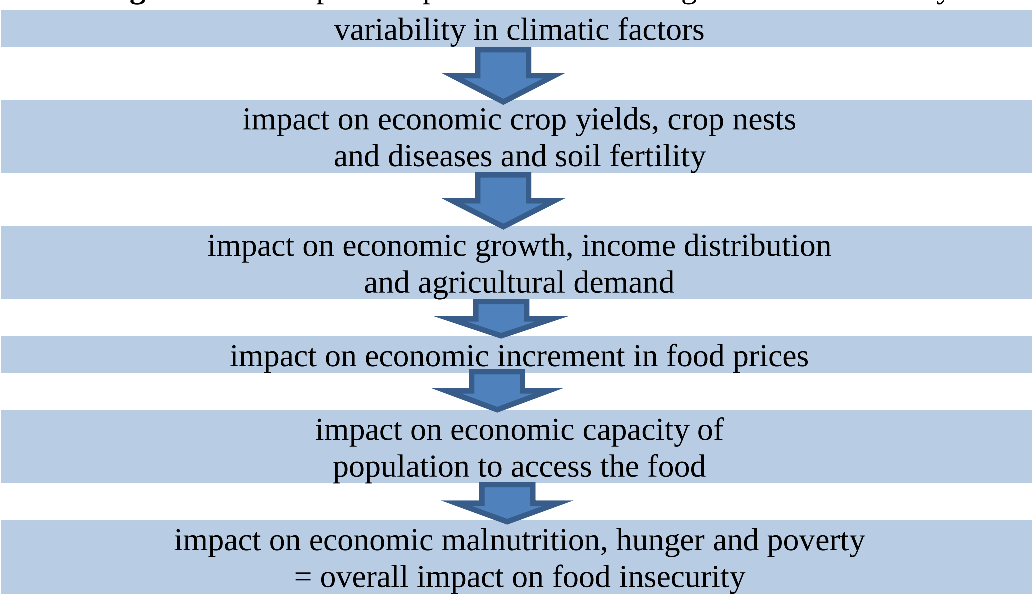
Mots - clés : insécurité alimentaire, stress climatique, ménages ruraux.

JEL: Q1, Q54, R2, R3

Introduction

A Sahelian-landlocked country in West Africa, Niger covers an area of 1,267,000 km^2. Three- quarters of the country is desert, including the Ténéré desert, which is one of the world's most austere deserts. The rainfall is characterized by a high variability in space and time from south to north as follows: The Sahel Sudan zone, which represents 1% of the total land area and receives between 600 and 800 mm of rain in normal years. It is conducive to agricultural and livestock production. The Sahelian zone covers 10% of the total land area with 350 to 600 mm of rain per year and is dominated by agriculture and pastoralism. The Sahel Saharan zone receives150 to 350 mm of precipitation per year on average and covers 12% of the total land area, it is characterized by moving livestock. The Saharan zone receives less than 150 mm of rain per year and extends over 77% of the total land area. The main objective of this paper is to assess the vulnerability of rural households to food insecurity given socioeconomic and climate factors based on estimating the probability of the occurrence of the different food insecurity categories. In Niger, climate change exacerbates increasingly the livelihoods of the population given that more than 80% of people rely on agriculture. Studying the factors of food insecurity can bring up policy makers for targeting key variables that strengthen the implementation of adaptation measures taking into account food insecurity and poverty eradication.

Figure 1: Conceptual impact of climate change on food insecurity



Source: author, 2018

1. Literature review

1.1 A brief review on food insecurity vulnerability and climate change

In the Sahelian countries in 1953, heavy rainfall destroyed crops and resulted in famine that persisted for the first nine months of 1954 and put the lives of around five million people in western and south-central Niger, northern Nigeria and northern Cameroon (Grolle, 1997) at risk. Since the two last decades, rainfall in the Sahel seemed to recover and floods have become more frequent than usual, most notably in 1995, 1998, 1999, 2002, 2003, 2005, 2006, 2007 and 2010 (Cook et al., 2011). Paeth et al., (2009) analyzed the conditions associated with widespread flooding in the region in 2007 and associated this phenomenon with a number of factors, including anomalous heating in the tropical Atlantic. In 2005, the number of Niger citizens suffering from severe food shortage was estimated to 3.2 million, of which 800,000 reached a critical threshold of food precariousness (SAP system d'alerte precause, and USAID FEWNET, 2005). In 2009, the cereal production deficit coupled with two consecutives forage deficits (31% of needs in 2008 and 67% in 2009) have resulted in a food crisis that has affected 7.1 million of people, of which 3.3 million ere categorized as severe (SAP: Système d'Alerte Précoce). In both cases, children were the most affected with global acute malnutrition rates above the emergency threshold of 15%. The food crisis of 2010 saw food prices rise to a level where they have remained since 2008. The terms of trade have followed a sharp degradation of the order of 30% compared to the average of the last five years during the peak of the lean pastoral period. Climate change and its variability affect significantly agricultural productivity resulting in several consequences such as food insecurity, hunger and poverty. The combination of environmental events (degradation of arable area, decreasing ground water, incredible wind, drought…) and socioeconomic factors (rising population, rising price of food grains, increasing cost of cultivation, low education level of farmers…) makes it difficult for vulnerable households to get rid of negative multidimensional, multi-processing, and complex phenomenon vulnerability (Shakeel et al., 2012). According to (Ramasamy and Moorthy, 2012), low agricultural productivity exacerbates the incidence of more poverty and hunger meaning that whatever the cause, Poverty and food security are intertwined (Rukhsana, 2011). Climate change can cause vulnerability to poverty in several ways. For instance, higher fluctuation in rainfall can result in drought or flooding which in turn may adversely affect households' assets and agricultural produce, leading to increment in poverty (Oluoko-Odingo and Alice, 2009). The variability of climate factors makes it difficult for country to grant food security for his people (Ahmad et al., 2011). Climate change is a real threat for agriculture as it affects crop yields, crop nests and diseases and soil fertility (Greg et al., 2011). All the economic sectors are negatively affected after a climate disaster resulting in severe shocks on economic growth, income distribution and agricultural demand (Schmidhuber and Tubiello, 2007) as well as volatility of food prices (Greg et al., 2011). Climate change exacerbates malnutrition, malaria and health problems resulting in hunger, food insecurity, poverty and malnutrition. Agricultural households are both exposed to environmental shocks and socioeconomic vulnerability as a result of demography, conflict with livestock breeders, illiteracy and poverty (Shakeel et al., 2012).

1.2 Measuring vulnerability to climate change

Literature on climate change vulnerability assessment focuses on three conceptual and theoretical frameworks, summarized as socioeconomic or social vulnerability - describing the adaptive capacity of a system, biophysical vulnerability - describing a system's sensitivity and exposure and finally, the combination of both approaches, known as the integrated assessment approach. Nelson et al., 2010a defines vulnerability as the susceptibility to disturbances determined by exposure to perturbations, sensitivity to perturbations, and the capacity to adopt. According to Cutter et al. (2009), vulnerability refers to the susceptibility of a given population, system, or place to harm from exposure to the hazard and directly affects the ability to prepare for, respond to, and recover from hazards and disasters. The SAR (second assessment repot) of the IPCC (intergovernmental panel on climate change) defines vulnerability as the extent to which climate change may damage or harm a system; not only a system's sensitivity is taken into account but also its adaptive capacity (Watson, Zinyowera, & Moss, 1996). From the definition given by the IPCC TAR (third assessment report), vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects to climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2001). IPCC AR4 is consistent with the definition of vulnerability given by TAR.

Biophysical vulnerability approach

The point of view of IPCC SAR is in line with the '*end point*' analysis in which the vulnerability of people is linked with external events depending on the development of possible climate scenarios and future climate trend. Hence, the level of vulnerability follows from studying the biophysical impacts of such climate changes, and finally, any residual adverse consequences despite collective actions taken after identification of adaptive capacity options (Kelly & Adger, 2000). From the point of view of end-point analysis, exposure and sensitivity cause linear impact leading to biophysical vulnerability. In the 'end point' analysis, researchers focus on biophysical drivers originating from extreme climatic events that are not under control of policy makers, such as drought, flood, temperature, and precipitation, and they view vulnerability as the resulting effect on the system after the climate hazard. For instance, modeling farm income on climate variables can help measure the monetary impact of climate change on agriculture (Mendelsohn, Nordhaus, and Shaw 1994; Polsky and Esterling, 2001; Sanghi, Mendelsohn, Dinar, 1998). By the same token, modeling crop yield and climate variables can help measure the yield impact of climate change (Adams 1989; Kaiser et al. 1993; Olsen, and Jensen 2000). Biophysical vulnerability assessment have been used in a variety of contexts, including the United States Agency for International Development (USAID), Famine Early Warning System (FEWS-NET) (USAID, 2007a), the World Food Program's Vulnerability Analysis and Mapping tool for targeting food aid (World Food Program, 2007), and a variety of geographic analysis that combine data on poverty, health status, biodiversity, and globalization (O'Brien et al., 2004; UNEP, 2004; Chen et al., 2006; Holt, 2007). The Human Development Index, for example, incorporates life expectancy, health, education, and standard of living indicators for an overall assessment of national well-being (UNDP, 2007). Biophysical vulnerability assessment also includes the impact of climate change on human mortality and health terms (Martens et al. 1999), on food and water availability (Du Toit, Prinsloo, and Marthinus 2001; FAO 2005; Xiao et al. 2002), and on ecosystem damage (Forner 2006; Villers-Ruiz and Trejo-Vázquez 1997). Füssel (2007) referred to this approach as a risk-hazard approach, while Adger (2000) referred to it as an approach responding to research questions such as "What is the extent of climate change problem?" and "Do the cost of climate change exceed the cost of greenhouse mitigation?". The biophysical approach has its limitation because it only accounts for physical losses, such as yield, income etc., without mentioning particular effective reductions due to climate change for different people or regions. In other words, it focuses more on sensitivity and exposure of individuals or social groups to climate change rather than adaptive capacity, which is explained more by their inherent characteristics Adger (1999), leading to uncertainty in vulnerability assessment (Nelson et al., 2010a). This method is therefore criticized because it treats humans as passive receivers of hazards.

Socioeconomic vulnerability approach

Many of the initial studies have focused on the adaptive capacity at the national level (Haddad, 2005; Adger & Vincent, 2005; Brooks et al., 2005; Adger et al., 2004; Yohe & Tol, 2002) and few of the latter studies have been focused at the sub national level

(Jakobsen, 2011; Nelson, et al., 2010b; Gbetibouo & Ringler, 2009). Social vulnerability assessment accounts for internal socioeconomic characteristics of people (Adger, 1999; Füssel, 2007) as individuals' status varies depending on education, gender, political power, social capital, etc. Thus, people are not socially vulnerable to the same extent because of their relative human-environmental properties that allow them to cope with changes, hence, setting up vulnerability to their adaptive capacity (Vincent & Cull, 2010; Vincent, 2004; Adger & Kelly, 1999; Adger, 1999). This type of vulnerability is called 'starting point' or present-day vulnerability, meaning individuals' internal characteristics before they are hit by hazard event (Allen 2003; Kelly and Adger, 2000) which itself originates from socioeconomic perturbations (Adger and Kelly, 1999). For example, Adger and Kelly (1999) used this in Vietnam when they considered environmental factors in a district to coastal lowlands as given and then measured individuals' vulnerability only depending on their intrinsic socioeconomic patterns. Although social vulnerability approach accounts for differences among individuals in society, it has its own limitation because people do not vary only due to socioeconomic characteristics, but also to environmental factors (Deressa et al., 2008). This approach neglects the environment-based intensities, frequencies, and probabilities of environmental shocks, particularly drought and flood. The divergence of academics' debate about the two approaches has resulted in the complexity of the term '*Biophysical*' vs. '*Social vulnerability*' (Vincent, 2004; Brooks, 2003) because the first approach cannot be completed without the latter nor the latter without the former given that hazard specificity is their common point. Therefore, combining both of them (*integrated vulnerability assessment)* simultaneously links social vulnerability (adaptive capacity) with biophysical aspects of climate change (exposure and sensitivity) to design a complete picture of vulnerability is the best methodological approach (Nelson et al., 2010b; Gbetibouo & Ringler, 2009; Cutter, 1996).

Integrated vulnerability approach

In this approach, both socioeconomic and biophysical factors are jointly considered to assess vulnerability, similarly like the example of hazard-of-place model (Cutter, Mitchell, and Scott, 2000) and mapping approach (O'Brien et al., 2004). The IPCC (2001) framework, which conceptualizes vulnerability to climate change as a function of adaptive capacity, sensitivity and exposure, is conducive with the integrated vulnerability assessment (Füssel and Klein, 2006; Füssel, 2007). Deressa et al., (2008) used the integrated vulnerability approach to assess farmer's vulnerability to climate change in Ethiopia. However, this approach has limitations. This approach does not allow for any standard method that helps combine indicators of biophysical and socioeconomic data sets. There is much to do to provide common metric for defining the relative importance of social and biophysical vulnerability and the relative importance of each individual variable. Furthermore, it does not account for the dynamism in vulnerability. To take advantage of opportunities, adaptive capacity options are to include the continual change of strategies (Campbell, 1999; Eriksen and Kelly, 2007); this dynamism is missing under the integrated assessment approach.

2. Methodology to estimate household food insecurity

"The first measure estimates the expected level of caloric consumption, based on household human and physical assets and capabilities, and compares it with the observed level of caloric consumption, below 2100 calories per capita per day into 3 categories of risk:

- o Extreme chronic level (A) of food insecurity level reflects both observed and expected levels of consumption below the minimum level of caloric consumption.
- o Vulnerability to chronic level (B) food insecurity summarizes the share of households with observed consumption levels below minimum level of caloric consumption, but have the human and physical assets that would allow them to consume adequate level of calories. However, they do not consume because of particular circumstances like droughts.
- o Vulnerability to food insecurity level (C) that summarizes the share of households exposed to risk and uncertainty, which had affected their levels of consumption. They are those who are expected to consume less than 2100 calories per capita a day in response to a shock, but manage to consume more.
- The overall level of food insecurity is measured by the sum of chronic (A) and transient food insecurity.

The second measure, named Dietary diversity calculates the food variety index**.** This index is a simple, or weighted, count of foods or food groups consumed over a given reference period. It emphasizes the importance of consuming a wide variety of food to enhance dietary quality. The main disadvantage of this method is that it does not take into account the quantity of food consumed or controls for diets regarding caloric composition. However, developing countries have a positive correlation of dietary diversity and nutrient adequacy.

The third measure uses the principal component analysis to reduce multidimensional data sets to lower dimensions for analysis of different outcomes."

Source: See Coates, Webb and Houser (2003); Hoddinott, J., and Y. Yohannes (2002); Migotto et al. (2006); del Ninno, Vecchi and Hussain (2006)

3. Data and methodology

3.1 Data

We used secondary data from Niger's National Institute of Statistics. It is a national database drawn from the socioeconomic national survey on vulnerability to food insecurity. It includes also data on rural households' perception of climate and environmental change and resulting shocks, agricultural and livestock information, coping strategies, social networks, infant feeding and gender. The survey is conducted in rural areas across all regions except for the north (Agadez) because of security issues in this region located in the desert.

3.2 Methodology: Multinomial logistic regression model of vulnerability of households to food insecurity in Niger

3.2.1 Description of food insecurity scores by national institute of statistics

The methodology adopted is to identify a number of variables that characterize the dimensions of classic analysis of food security. The variables identified for this purpose are food consumption score, livestock ownership and expenses.

- For each indicator, a reference threshold based on the existing secondary data was calculated.

The whole household was ordered increasingly against each indicator and divided into five homogeneous groups. Each group has about 20% of households. For each group of 20%, a value average was calculated. These average values are the thresholds for each indicator.

Some variables undergone preliminary transformations:

a) The food consumption score

It is calculated by combining all foods consumed in 10 groups: cereals, tubers, legumes, protein, milk, egg, vegetables, fruits, sugar, and oil.

The maximum score is 7x10 = 70. The score for each household is divided by 70 (this value may be lower if one considers less groups or greater if one considers more groups, either way the thresholds are the same). The entire household is then ordered in relation to this standard score and divided into 5 groups. For each group, an average of scores was calculated and resulted in the following threshold:

Very poor consumption (score between 0 and 0.27; rank = 1), poor consumption (score between 0.27 and 0.43; rank = 2), average consumption (score between 0.43 and 0.52; rank = 3), acceptable consumption (score greater than 0.52; rank = 4)

b) Livestock ownership

Livestock ownership in TLU (tropical livestock unit) for adding goats, sheep, oxen… One TLU equals to a 250kg cow; heifer beef = 0.8 TLU; bull = 0.8 TLU; young bull = 0.8 TLU; calf = 0.8 TLU; camel = 0.8 TLU; sheep = 0.8 TLU; goat = 0.8 TLU. To take account of different life system, this indicator was inversely weighted according to the weighting coefficients of the early warning system institution (0.6 for the pastoral zone, 0.32 for agropastoral zone, and 0.06 for agricultural zone. For instance, a household having 2 TLU in pastoral zone will have a value of 2/0.6 = 3.33 and will have 2/0.06 = 33.33 in agricultural zone. The thresholds for this indicator are the following:

0 TLU does not own animals (rank = 1); between 0 and 0.05 have very few animals (rank = 2); between 0.05 and 0.21 have some animals (rank = 3); greater than 0.21 have many animals (rank = 4).

c) Household spending

The following thresholds were considered for expenses: < 0.4 US $ / day / person, very expense low (rank = 1); > 0.4 US $ / day / person and < 0.6 US $ / day / person, low expense (rank = 2); > US $ 0.6 and < 0.8 US $, average expense (rank = 3); > 0.8 US $ / day / person, high expense (rank = 4).

- For each household, the value for each indicator was compared with the calculated thresholds and rank has assigned.
- Principal component analysis based on the assigned ranks was calculated so as to define a set of homogeneous households based on the indicators.
- Adjustment and consolidation of households obtained on the basis of additional indicators characterizing household food security and the livelihood risk.
- Characterization household profile affected by food insecurity or risk to their livelihoods.
- Identification of departments, regions, agroecological zones based on the proportions of households in food insecure.

3.2.2 Description of the model

The dependent variable, food security status is a categorical variable:

Food security categories: 0 = safe; 1 = moderate; 2 = at risk; 3 = severe

In our case, it can be set as following:

$$\mathbf{Prob}(Y_i = j|w_i) = \frac{e^{w_i'\alpha_j}}{\sum_{j=0}^{3} e^{w_i'\alpha_j}} = \mathbf{Prob}(Y = 1|X_i), j = 0, 1, \ldots, 3 \qquad 1)$$

The estimated equations provide a set of probabilities for the J + 1 choices for a decision maker with characteristics w_i.

Before proceeding, we must remove an indeterminacy in the model. A convenient normalization that solves the problem is $\alpha_0 = 0$. (This arises because the probabilities sum to one, so only J parameter vectors are needed to determine the J + 1 probabilities.) Therefore, the probabilities are:

$$\mathbf{Prob}(Y_i = j|w_i) = P_{ij} = \frac{e^{w_i'\alpha_j}}{1+\sum_{j=1}^{J} e^{w_i'\alpha_j}} = \mathbf{Prob}(Y = 1|X_i), j\ 0, 1, \ldots, J \qquad 2)$$

In this model, the coefficients are not directly tied to the marginal effects. The marginal effects for continuous variables can be obtained by differentiating (2) with respect to a particular factor w_m to obtain:

$$\frac{\partial P_{ij}}{\partial w_{im}} = ((P_{ij}\ (1(j = m)\ -\ P_{im})), m = 0, 1, \ldots, J \qquad 3)$$

It is clear that through its presence in Pij and Pim, every attribute set w_m affects all the probabilities. One might prefer to report elasticities of the probabilities. The effect of attribute k of choice m on Pij would be:

$$\frac{\partial lnP_{ij}}{\partial lnw_{mk}} = w_{mk}(P_{ij}\ (1(j = m))\alpha_k \qquad 4)$$

In the multinomial logit model, we estimate a set of coefficients, α (1), α (2), and α (3), corresponding to each outcome:

$$\mathbf{Prob}\ (y = 1) = \frac{e^{w'\alpha(1)}}{e^{w'\alpha(1)} + e^{w'\alpha(2)} + e^{w'\alpha(3)}} \qquad 5)$$

$$\mathbf{Prob}\ (y = 2) = \frac{e^{w'\alpha(2)}}{e^{w'\alpha(1)} + e^{w'\alpha(2)} + e^{w'\alpha(3)}} \qquad 6)$$

$$\mathbf{Prob}\ (y = 3) = \frac{e^{w'\alpha(3)}}{e^{w'\alpha(1)} + e^{w'\alpha(2)} + e^{w'\alpha(3)}} \qquad 7)$$

Setting α (1) = 0, the equations become:

$$\text{Prob}\ (y=1) = \frac{1}{1+e^{w'\alpha(2)}+e^{w'\alpha(3)}} \qquad 8)$$

$$\text{Prob}\ (y=2) = \frac{e^{w'\alpha(2)}}{1+e^{w'\alpha(2)}+e^{w'\alpha(3)}} \qquad 9)$$

$$\text{Prob}\ (y=3) = \frac{e^{w'\alpha(3)}}{1+e^{w'\alpha(2)}+e^{w'\alpha(3)}} \qquad 10)$$

For instance, the relative probability of y = 2 to the base outcome is:

$$\frac{\text{Prob}\ (y=2)}{\text{Prob}\ (y=1)} = e^{w'\alpha(2)} \qquad 11)$$

Let's call this ratio the relative risk. The relative risk ratio for a one-unit in w_i is then $e^{\alpha(2)}$. Thus, the exponential value of a coefficient is **the Relative-Risk Ratio (RRR)** for a one-unit change in the corresponding variable (risk is measured as the risk of the outcome relative to the base outcome). In terms of the process for choosing the best model, it is based on the log likelihood. We used an ascending procedure starting to put in the model, among the explanatory variables, a variable which is the most associated with the dependent variable according to the bivariate descriptive analysis. Then, the other variables, are successively added to the model according to their degree of association revealed in the descriptive analysis; if the addition of a variable increases the log-likelihood it is kept in the model. The final model is one that maximizes the likelihood log and contains the maximum of variables of which at least one modality is statistically significant.

In the table below, at 10% confidence level, all the independent are associated to food insecurity except age, daily milk expense and daily meat expense. Regarding the sex of household head, female is slightly the most affected by food insecurity than male: severe 8.6% against 6.0%, moderate 7.1% against 7.5%, at risk 34.9% against 29.6%, secure 49.4% against 57%.
The table shows that households who possess the most animals are less affected by severe food insecurity than households without animals: 5.1% against 12.7%.

Table1: Bivariate descriptive analysis test between dependent and independent variables

Independent variables	**Dependent variable:** Food security categories				
	Severe	Moderate	At risk	safe	**P value**

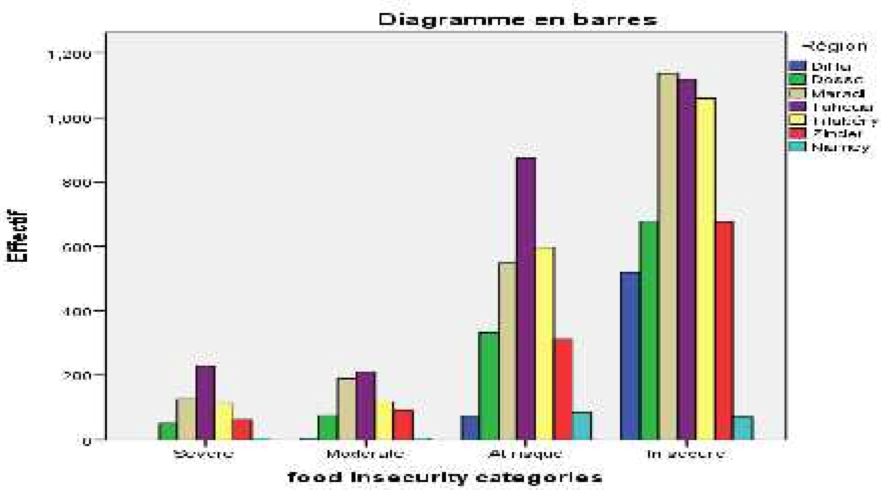
					Chi 2
Household size					0.000
Age					.266
Household sex					.000
1 = Male (outcome)	6.0%	7.5%	29.6%	57%	
2 = Female	8.6%	7.1%	34.9%	49.4%	
Animal possession					.000
1 = yes	5.1%	6.5%	27.8%	60.6%	
2 = no (outcome)	12.7%	12.3%	42.7%	32.3%	
	6.0%	7.2%	29.9%	56.9%	
	9.4%	7.4%	31.9%	48.7%	
Number of fields / gardens operated					.000
Education spending last 12 month					.082
1 = yes	5.8%	7.9%	30.0%	55.3%	
2 = no (outcome)	6.9%	7.1%	30.2%	56.9%	
Agricultural/tools/seeds spending this year					.000
1 = yes	5.0%	5.9%	28.7%	60.3%	
2 = no (outcome)	8.0%	9.5%	31.9%	57.1%	
Flood					.000
1 = yes	9.0%%	8.1%%	30.1%	52.7%	
2 = no (outcome)	5.5%%	7.2%	30.1%	80.9%	
Drought					.000
1 = yes	11.5%	6.9%	28.5%	53.0%	
2 = no (outcome)	5.4%	7.5%	30.3%	56.7%	
Daily milk consumption expense					.456
Daily fruits consumption expense					.087
Daily meat consumption expense					.293
Daily cooked food consumption expense					.002

Source: author, 2018

In the last 12 months, the following is the proportion of households in severe food insecurity: households who have operated field or gardens 6.0% against 9.4% who have not, households who have spent in education 5.8% against 6.9% who have not, households who have spent in agricultural tools or seeds 5.0% against 5.5% who have not. Households who have experienced flood over the last or the last 3 years are less food secure 52.7% than households who did not 80.9%. The severe food insecurity effects those who are the most exposed to drought occurrence 11.5% than those who are not 5.4% and are those whose households are less food secure 53.0% against 56.7%.

The table shows the depth of food insecurity in rural areas whether it is severe, moderate or risky. The conclusion is that food insecurity sets apart no body when it occurs.

Figure 2: Food insecurity in rural areas by regions



Source: author, 2018

The figure above gives the distribution of food insecurity in rural areas in the different regions. The figure shows that households in food secure are larger than those at risk and only few of them are in severe or moderate food security. Niger is ranked among the poorest in the world and its economy remains dominated by the primary sector. Despite its importance, agriculture is struggling with its modernization and is largely dependent on weather conditions. In addition, the high population growth of the country is increasing pressure on land with a resulting continuous farms fragmentation and the expansion of crops on marginal land with decreasing returns. This heavy dependence on rain-fed agriculture predisposes the country to a great food vulnerability and years of low agricultural production generally result in recurrent food crisis whose breadth and depth vary depending on the level of deficit and the prevailing cyclical factors. The year 2009/2010 was a year of acute pastoral and nutrition food crisis which affected the half population of Niger. The crisis has also resulted in large losses of animals due to lack of pasture, high rainfall and flooding.

4. Results and interpretation of the Risk-Relative Ratio RRR

Table2: Multinomial logistic regression coefficients

Multinomial logistic regression — **Number of obs = 3182**
LR chi2(39) = 278.47
Prob > chi2 = 0.0000
Log likelihood = -2998.6656 — **McFadden R 2 or Pseudo R2 = 0.0444**

Independent variables	**Dependent variable:** Food security categories: safe is taken as the reference category					
	Severe		Moderate		at risk	
	Coef	**P value**	**Coef**	**P value**	**Coef**	**P value**
Household size	.084*	0.000	.027	0.178	.015	0.211
Age	-.010***	0.080	-.001	0.788	-.005**	0.040
Household sex						
1 = Male (reference)						
2 = Female	.340	0.279	-.279	0.377	.173	0.290
Animal possession						
1 = yes	-1.526*	0.000	-1.032*	0.000	-1.147*	0.000
2 = no (reference)						
Number of fields / gardens operated	-.191**	0.006	-.370*	0.000	-.095*	0.001
Education spending last 12 month						
1 = yes	.494***	0.009	.509*	0.001	.332*	0.000
2 = no (reference)						
Agricultural/tools/seeds spending this year						
1 = yes	-.554**	0.002	-.753*	0.000	-.171***	0.056
2 = no (reference)						
Flood occurrence this year						
1 = yes	.647*	0.001	.751*	0.000	.073**	0.500
2 = no (reference)						
Drought occurrence this year						
1 = yes	.456**	0.050	.042	0.841	.192	0.123
2 = no (reference)						
Daily milk consumption expense	.017	0.779	-.141***	0.090	.010	0.743

Daily fruits consumption expense	-.055	0.872	.134	0.141	-.411***	0.067
Daily meat consumption expense	.064	0.641	-.379**	0.043	-.095	0.274
Daily cooked food consumption expense	-.032	0.661	.064	0.166	-.025	0.464

Source: author, 2018.

*, ** and *** indicates the 1%, 5% and 10% significance level of regression coefficient for respective variables in the table.

The interpretation of our results concerns the relative risk ratios (RRR) instead of regression coefficients, the probability threshold is set at 10%. The numerical values of the coefficients do not have direct interpretation; however, their positive or negative signs are interpretable. The sign indicates whether the probability of observing a particular category of the dependent variable is an increasing or decreasing function of the corresponding predictor or explanatory variable (all other things being equal). Thus, the results of the table above call for several comments. The coefficient regression of household size is significantly positive: the number of household members increases the probability for a household to be severely food insecure. Age is a factor that reduces the probability for a household to be severely food insecure or at risk. The probability for a household to be severely food insecure, moderate or at risk, decreases with animal possession. The number of fields or gardens cultivated reduces the probability for a household to be exposed to food insecurity (severe, moderate or at risk). The share of household spending devoted to education exposes a household to food insecurity vulnerability. Agricultural/tools/seeds spending make household better off with against food insecurity. Experiencing climate stress event such as flood and drought increases the probability for a household to be severely food insecure, moderate or at risk. Food insecurity is moderate for households who spend in milk, fruits and meat consumption. The value of the relative risk is interpreted as follow: if the factor studied does not play a causal role, there should be no difference in incidence between those exposed and non-exposed: in this case, the relative risk must be equal to 1; if it is greater than 1, this means that the presence of factor causes an increase in the probability of occurrence of the disease (or a decrease in the probability if it is less than 1). A relative risk of 3 (or 10) should be interpreted as follows: the subjects exposed to the risk factor have a probability 3 times (10 times) higher to have the disease than the non-exposed. The term relative risk is that the incidence is a measure of the risk of disease in the population (recall that the risk is the probability of an event).

The relative risk is the ratio of two risks (the risk for the exposed and the risk for the unexposed). A RRR < 1 indicates a beneficial effect, a RRR > 1 indicates a negative effect, a RRR = 1 indicates that the event frequency is the same for the exposed group and the unexposed group.

Analysis of the different climatic projections by AGRHYMET indicates that food security is far from being provided in the future. There is a visible gap between the food needs of a fast-growing population and probable agricultural production. Under the influence of population pressure, the gap could, in the long term, have an exponential trend (resulting in a demand/probable production balance sheet) that will always be negative because millet, sorghum and cowpea are incredibly sensitive to their environmental conditions and production. The major impact of rainfall decline will be soil degradation, decline in agricultural production, and chronic distribution of food supply. There is also an expected continuous large-scale movement of populations, an increase in diseases, and an important loss in terms of biodiversity. The evolution of agricultural production in the Sahel countries, in general, and in Niger, in particular, during the last twenty years showed that one out of two years resulted in a deficit. Indeed, if the crop year 2005/2006 was characterized by a grain surplus of 21.000 tons at the national level, that of 2004/2005 recorded a deficit of about 223.000 tons.

Table3: Relative risk associated to food insecurity

Multinomial logistic regression **Number of obs = 3182**
LR chi2(39) = 278.47
Prob > chi2 = 0.0000
Log likelihood = -2998.6656 McFadden R 2 or Pseudo R2 = 0.0444

Independent variables	**Dependent variable:** Food security categories: safe is taken as the reference category					
	Severe		Moderate		at risk	
	RRR	P value	**RRR**	P value	**RRR**	P value
Household size	1.087*	0.000	1.028	0.178	1.015	0.211
Age	.989***	0.080	.998	0.788	.994**	0.040
Household sex						
1 = Male (reference)						
2 = Female	1.405	0.279	.756	0.377	1.188	0.290
Animal possession						

1 = yes	.217*	0.000	.356*	0.000	.317*	0.000
2 = no (reference)						
Number of fields / gardens operated this year	.825*	0.006	.690*	0.000	.908*	0.001
Education spending this year						
1 = yes	1.640*	0.009	1.665*	0.001	1.394*	0.000
2 = no (reference)						
Agricultural/tools/seeds						
spending this year	.574**	0.002	.470*	0.000	.842***	0.056
1 = yes 2 = no (reference)						
Flood occurrence this year						
1 = yes	1.910*	0.001	2.120*	0.000	1.076**	0.500
2 = no (reference)						
Drought occurrence this year						
1 = yes	1.577**	0.050	1.043	0.841	1.212	0.123
2 = no (reference)						
Daily milk consumption expense	1.017	0.779	.868***	0.090	1.010	0.743
Daily fruits consumption expense	.945	0.872	1.144	0.141	.662***	0.067
Daily meat consumption expense	1.066	0.641	.684**	0.043	.908	0.274
Daily cooked food consumption expense	.968	0.661	1.066	0.166	.974	0.464

Source: author, 2018. *, ** and *** indicates the 1%, 5% and 10% significance level of regression coefficient for respective variables in the table.

All other things being equal, compared with food security, households with higher size have a probability 1.087 times higher to be severely food insecure in the exposed group than in the unexposed group. Compared with food security, heads of household with higher age have a probability .989 times lower to be severely food insecure and a probability .994 times lower to be at risk in the unexposed group than in the exposed group respectively. Compared with food security, the probability is .217 to .356 times lower to be food insecure or at risk for households possessing animals than households without animals. Compared with food security, households with higher number of cultivated fields are more than .9 times less likely to be severely food insecure, moderate or at risk in the unexposed group than in the exposed group. Compared with food security, households who spend in the education of their children in the last 12 months have a probability more than 1.394 higher to be affected by severe food insecurity, moderate or at risk than households who devote any part of their budget in the education of their children in the last 12 months. Compared with food security, the probability of being in severe food insecurity, moderate or at risk, is more than 0.470 lower for households who spent in agriculture in the year than households who spent any part of their budget in agriculture. Compared with food security, households who experienced flood occurrence in the year, have a probability 1.910 times higher, 2.120 times higher and 1.076 times higher to be affected by food insecurity whether it is severe, moderate or at risk respectively than households who did not suffer from flood occurrence in the year. Compared with food security, households who suffered from drought occurrence in the year, have a probability 1.577 times higher to be severely food insecure than households who did not experience drought occurrence in the year. Compared with food security, households with higher daily milk consumption expense are .868 less likely to be affected by food insecurity (moderate) in the unexposed group than in the exposed group. Compared with food security, households with higher daily fruits consumption expense are .662 less likely to be affected by food insecurity (at risk) in the unexposed group than in the exposed group. Compared with food security, households with higher daily meat consumption expense are .684 less likely to be affected by food insecurity (moderate) in the unexposed group than in the exposed group.

5. Discussion

This study shows that the number of individuals to feed exposes a household to severe food insecurity. This situation is due to the fact that more than seven in ten households live in poverty in poverty, in rural areas, the majority of households (71%) have their income below the poverty line (Illa, 2014) and poor households are the most exposed to food insecurity (Kimani Murage-EW et al, 2014; Chinnakali P. et al, 2014; Vogt and Tarasuk V. J, 2009). Any policy encouraging the reduction of household members can increase the probability for the household to be food secure. The age of the household head has positive and significant relationship with household food security (Fekadu Beyene and Mequanent Muche, 2010). Age is a factor that reduces vulnerability to food insecurity because of the experiences accumulated in the past in agricultural practices. Animal possession and number of fields operated make households better off as they can sale few animals and/or fields as coping strategies to protect themselves against food insecurity. In rural areas, larger livestock and/or fields are important indicator of wealth. Households possessing larger livestock and fields are found to be less vulnerable to food insecurity in Ethiopia (Fekadu Beyene and Mequanent Muche, 2010). Extending arable and grazing land area can contribute to reduce the probability of households to be food insecure. Education expenses are a burden for food insecure households, this seems logical since the education expenses reduce the share of food expenditures for households who struggle to achieve food security. Agricultural expenditure on seeds and fertilizers improve soil fertility and crop yields resulting in food insecurity reduction. Policy implication granting seed and fertilizer subsidies will increase the probability of households to be food secure. Drought and flood are constant threats to food insecurity affecting several sectors and resulting in income losses. The supply reduction causes food prices to rise making it difficult for the households to meet the food needs of its members. Food insecurity has become more frequent in recent years because of drought and flood occurrence with many severe impacts including crop losses, lower yields in both crop and livestock production, land degradation and soil erosion.

Conclusion and policy implication

This study has showed the determining factors that are significantly linked to food insecurity in rural areas. The most affected households are those having large size, those who devote a part of their expenses in the education of their children in the year preceding the food insecurity occurrence, and those who have experienced flood and drought event in the year preceding the food insecurity occurrence. From the model results, we learn that animal possession, the number of cultivated fields, expenses on agricultural tools and seeds reduce the risk of exposure to food insecurity. In view of these results, for the effectiveness of the fight against food insecurity, a political from authorities that strives to master the control factors associated with it is needed. Policies and strategies that involve the control of agricultural input prices and subsidies on chemical fertilizers and seeds are essential to sustain the fight against food insecurity. The lack of such a policy could make it difficult for households to purchase agricultural inputs if there is a rise of input prices because of the depletion of food supply as a result of drought or flood. It is important to study the determinants of food insecurity but it is also interesting, for further research, to find out what are the strategies developed firstly by households in food security to address food insecurity and secondly by those who suffer.

References

Adams, R. M. (1989). Global climate change and agriculture: An economic perspective. American Journal of Agricultural Economics 71(5): 1272–1279.

Adger, W. N. (2000). Social and ecological resilience: are they related? Progress in Human Geography 24(3): 347-364

Adger, W. N., (1999). Social Vulnerability to Climate Change and Extremes in Coastal Vietnam. World Development 27 (2), 249-269, 1999.

Adger, W. N., & Vincent, K. (2005). Uncertainty in Adaptive Capacity. C R Geoscience, 337 399 - 410.

Adger, W. N., N. Brooks, G. Bentham, M. Agnew and S. Eriksen (2004). "New indicators of Vulnerability and adaptive capacity." Norwich, UK: Tyndall Centre for Climate Change.

Adger, W. N., & Kelly, P. M. (1999). Social Vulnerability to Climate Change and the Architecture of Entitlements. Mitigation and Adaptation Strategies for Global Change, 4, 253 - 266.

Ahmad, J, A. Dastgir, and S. Haseen (2011), 'Impact of climate change on agriculture and Food security in India', International Journal of Agricultural Environmental and Biotechnology 4 (2):129-137.

Allen, K. (2003). Vulnerability reduction and the community-based approach: A Philippines study. In Natural Disasters and Development in a Globalizing World, ed. M. Pelling, 170–184, New York: Routledge.

Brooks, N., W. N. Adger, and P. M. Kelly. (2005). The determinants of vulnerability and adaptive Capacity at the national level and the implications for adaptation. Global Environmental Change 15(2): 151–163.

Brooks, N. (2003). Vulnerability, Risk and Adaptation: A Conceptual Framework. Working Paper 38. Norwich: Tyndall Centre for Climate Change Research.

Campbell, D. J. (1999). Response to drought among farmers and herders in southern Kajiado District, Kenya: A comparison of 1972–1976 and 1994–1995. Human Ecology 27: 377-415.

Chaudhuri, S., J. Jalan, and A. Suryahadi. (2002). Assessing household vulnerability to poverty: A Methodology and estimates for Indonesia. Department of Economics Discussion Paper 0102-52. New York: Columbia University.

Chen, J.T., Rehkopf, D.H., Waterman, P.D., Subramanian, S.V., Coull, B.A., Cohen, B., Ostrem, M., Krieger, N., (2006). Mapping and measuring social disparities in premature mortality: The impact of census tract poverty within and across Boston neighborhoods, 1999-2001. Journal of Urban Health 83, 1063-1084.

Coates, J., P. Webb, and R. Houser (2003). 'Measuring Food Insecurity: Going Beyond Indicators of Income and Anthropometry'. Food and Nutrition Technical Assistance Project. Washington, DC: Academy for Educational Development.

Cook et al., (2011). Forced and unforced variability of twentieth century North American droughts and pluvials. Clim. Dyn., 37, 1097-1110, doi:10.1007/s00382-010-0897-9.

Cutter, S. L., Emrich, C. T., Webb, J. J., & Morath, D. (2009). Social Vulnerability to Climate Variability Hazards.

Cutter, S. L. (1996). Vulnerability to Environmental Hazards. Progress in Human Geography, 20(4), 529 - 539.

Cutter, S. L., J. T. Mitchell, and M. S. Scott. (2000). Revealing the vulnerability of people and Places: A case study of Georgetown County, South Carolina. Annals of the Association of American Geographers 90(4): 713–737.

Du Toit, M. A, S. Prinsloo, and A. Marthinus. (2001). El Niño-southern oscillation effects on Maize production in South Africa: A preliminary methodology study. In Impacts of El Niño and climate variability on agriculture, eds. C. Rosenzweig, K. J. Boote, S.

Eriksen, S. H., and P. M. Kelly. (2007). Developing credible vulnerability indicators for climate Adaptation policy assessment. Mitigation and Adaptation Strategies for Global Change 12(4): 495–524.
Fekadu Beyene and Mequanent Muche (2010), Determinants of Food Security among Rural Households of Central Ethiopia: An Empirical Analysis.

Forner, C. (2006). An introduction to the impacts of climate change and vulnerability of forests. Background document for the South East Asian meeting of the Tropical Forests and Climate Change Adaptation (TroFCCA) project. Bogor, West Java (May 29–30).

Füssel, H.-M., and R. J. T. Klein. (2006). Climate change vulnerability assessments: An Evolution of conceptual thinking. Climatic Change 75(3): 301–329.

Füssel, H. (2007). Vulnerability: A generally applicable conceptual framework for climate change Research.

Gbetibouo, G. A., & Ringler, C. (2009). Mapping South African Farming Sector Vulnerability to Climate Change and Variability. A Sub National Assessment. IFPRI Discussion Paper 00885. Washington, DC: International Food Policy Research Institute (IFPRI).

Greg, E.E., B.E. Anam, M.F. William, and EJC Duru (2011), 'Climate change, food security and agricultural productivity in African: Issues and policy directions', International Journal of Humanities and Social Science 1 (21)205-223.

Grolle, J. (1997). 'Heavy rainfall, famine, and cultural response in the West African Sahel: the "Muda" of 1953–54', Geo Journal, Vol. 43, No. 3, pp. 205–214.

Haddad, B. M. (2005). Ranking the adaptive capacity of nations to climate change when socio-Political goals are explicit. Global Environmental Change, 15, 165-176.

ILLA (2015), Vulnerability of rural households to climate stress across regional levels in Niger.

IPCC, Intergovernmental panel on Climate Change. (2001). Climate change 2001: Impacts, Adaptation and Vulnerability. Cambridge University Press.

Jakobsen, K. (2011). Livelihood asset maps: a multidimensional approach to measuring Risk- Management capacity and adaptation policy targeting-a case study in Bhutan. DOI 10.1007/s10113-012-0320-7.

Kaiser, H. M., S. J. Riha, D. S. Wilks, D. G. Rossiter, and R. K. Sampath. (1993). A farm-level Analysis of economic and agronomic impacts of gradual warming. American Journal of Agricultural Economics75: 387–98.

Kelly, P. M., and W. N. Adger. (2000). Theory and practice in assessing vulnerability to climate Change and facilitation adaptation. Climatic Change 47(4): 925–1352.

Kimani-Murage E. W, Schofield L, Wekesah F, Mohamed S, Mberu B., Ettarh R, Egondi T, Kyobutungi C, Ezeh A. (2014), « Vulnerability to Food Insecurity in Urban Slums: Experiences from Nairobi, Kenya », Journal of Urban Health: Bulletin of the New York Academy of Medicine, doi:10.1007/s11524-014-9894-3.

Martens, P., R. Kovats, S. Nijhof, P. de Vries, J. Livermore, D. Bradley, et al. (1999). Climate Change and future populations at risk of malaria. Global Environmental Change 9(1): 89–107.

McCarthy, J., O. F. Canziani, N. A. Leary, D. J. Dokken, and C. White, eds. (2001). Climate Change 2001: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the Third assessment report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Mendelsohn, R., W. Nordhaus, and D. Shaw. (1994). The impact of global warming on Agriculture: A Ricardian analysis. American Economic Review 84: 753-771.

Nelson, R., Kokic, Crimp, S., Meinke, H., & Howden, S. M. (2010a). The vulnerability of Australian Rural Communities to Climate Change Variability and Change.

Nelson, R., Kokic, P., Crimp, S., Martin, P., Meinke, H., Howden, S. M., et al. (2010b). the Vulnerability of Australian Rural Communities to Climate Variability and Change: Part II - Integrating Impacts with Adaptive Capacity. Environmental Science and Policy, 13, 18 -27.

O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., Javed, A., Bhadwal, S., Barg, S., Nygaard, L., West, J., (2004). Mapping vulnerability to multiple Stressors: climate change and globalization in India. Global Environmental change 14, 303-313.

Olsen, J. E., P. K. Bocher, and Y. Jensen. (2000). Comparison of scales of climate and soil data for Aggregating simulated yields in winter wheat in Denmark. Agriculture, Ecosystem and Environment 82(3): 213–228.

Oluoko-Odingo, and A. Alice (2009), ‘Determinants of poverty: lessons from Kenya’, Geo Journal 74:311–331.

Paeth, H., Fink, A. and Samimi, C. (2009). ‘The 2007 flood in sub-Saharan Africa: Spatio-Temporal characteristics, potential causes, and future perspective’, EMS Annual Meeting Abstracts, Vol. 6, EMS2009-103.

Polsky, C., and W. E. Esterling. (2001). Adaptation to climate variability and change in the US Great Plains: A multi-scale analysis of Ricardian climate sensitivities. Agriculture, Ecosystem and Environment 85(3): 133–144.

Ramasamy, J., and P. Moorthy (2012), ‘Managing food insecurity and poverty in India in the area of globalization’, International Journal of Multidisciplinary Research 2 (1):411421.

Rukhsana (2011), ‘Dimension of food security in a selected state Uttar Pradesh’, Journal of Agricultural Extension and Rural Development 3 (2):29-41.

Sanghi, A., R. Mendelsohn, and A. Dinar. (1998). The climate sensitivity of Indian agriculture. In measuring the impact of climate change on Indian agriculture, ed. A. Dinar et al. (Technical Paper 402). Washington, DC: World Bank.

Schmidhuber, J., and F.N. Tubiello (2007), ‘Global food security under climate change’, Proceedings of the National Academy of Sciences of the United States of America 104 (50): 581-596.

Shakeel, A., A. Jamal, and M.N. Zaidy (2012), ‘A regional analysis of food security in Bundelkh and region Uttar Pradesh (India)’, Journal of Geography and Regional Planning 5 (9):252-262.

Temesgen Deressa, Rashid M. Hassan and Claudia Ringler. (2008). Measuring Ethiopian Farmer’s Vulnerability to Climate Change across Regional States.

UNDP, (2007). Human development reports. http://hdr.undp.org/en/ (accessed 25 December 2007).

UNEP. (2004). Poverty-biodiversity mapping applications. In: Presented at: IUCN World Conservation Congress, Bangkok, Thailand, 17-25 November 2004.

USAID (2007a). Famine Early Warning Systems-NETwork (FEWS-NET). http://www.fews.net/ (Accessed 24 December 2007). Villers-Ruiz, L., and I. Trejo-Vázquez. 1997. Assessment of the vulnerability of forest Ecosystems to climate Change in Mexico. Climate Research 9 (December): 87–93.

Vincent, K. (2004). Creating an index of social vulnerability to climate change for Africa. Working Paper 56. Norwich: Tyndall Center for Climate Change Research.

Vincent, K., & Cull, T. (2010). A Household Social Vulnerability Index (HSVI) for Evaluating Adaptation Projects in Developing Countries. Paper presented in PEG Net Conference 2010, Policies to Foster and Sustain Equitable Development in Times of Crises, Midrand, 2nd -3rd September 2010.

Watson, R. T., Zinyowera, M. C., & Moss, R. H. (1996). Adaption and Mitigation of Climate Change.

World Food Program. (2007). Vulnerability Analysis and Mapping tool for targeting food aid.

Xiao, X., et al., (2002). Transient climate change and potential croplands of the world in the 21st Century. Massachusetts Institute of Technology, Joint Program on the Science and Policy of Global Change, Report No. 18. Cambridge: MIT

Yohe, G., & Richard S.J Tol (2002). Indicators for social and economic coping capacity-moving toward a working definition of adaptive capacity. Global Environmental Change 12 (2002) 25-40.

This paper was presented at the Conference on Climate Change and Food Security in West Africa co-organized by Université Cheikh Anta Diop de Dakar (UCAD) and Center for Development Research (ZEF), University of Bonn, on 17-18 November 2019 in Dakar, Senegal.